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XIII.—*A Trematode from* Protopterus.

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THROUGH the kindness of Mr. G. A. K. Marshall, of the Imperial Bureau of Entomology, an opportunity has recently been afforded me of studying a very interesting little Trematode parasite from the intestines of an African mud-fish (*Protopterus æthiopicus*). A considerable number of specimens of the worm were obtained by Dr. G. D. H. Carpenter at Lake Victoria, Uganda.

The species, which I believe to be new to science, possesses not only a borrowed interest on account of the much-discussed position of its host in the animal kingdom, and the fact that its parasites have not (so far as I am aware) hitherto been explored, but also considerable intrinsic interest on account of certain structural peculiarities and its probable systematic relationships.

It is much to be regretted that the material was imperfectly fixed and rather macerated, rendering the cutting of satisfactory sections difficult, so that some of the details of the anatomy must remain for the present doubtful. The main features, however, have not been difficult to make out, and in collecting the data for the following description I have relied as far as possible upon specimens either temporarily cleared and mounted in creosote or stained and mounted whole in balsam. The various series of sections that have been cut have proved useful mainly in confirming conclusions at which I had previously arrived from the examination of the whole preparations.

Heterorchis crumenifer, gen. et sp. n.*

EXTERNAL FEATURES.

The contour of the animal, as seen from above or below, is oval, tapering slightly towards either end. Anteriorly the body is flattened, but posteriorly the ventral side is much swollen by the development of the uterus, so that the body is more cylindrical in this region. The total length of the animal (without pressure) is about 3 mm., and its maximum width, under the same conditions, 1 mm.

The exterior of the body is armed with small, flattened scales, semicircular in outline; they occur on the oral and ventral suckers and on the anterior part of the body, both dorsally and ventrally, extending backwards for a short distance behind the ventral sucker. Somewhat larger scales also occur along the sides of the body for about three-quarters of its length. The posterior end of the body is without scales, and in some of the older individuals many of the scales on the more anterior parts appear to have fallen off, leaving almost the entire body smooth.

The oral sucker measures 0·38 to 0·46 mm. in diameter, and has a small opening. The ventral sucker is larger, having a diameter of 0·55–0·72 mm., and has a wide aperture. On an average, obtained from the measurements of nine individuals, the ratio of the diameter of the oral to that of the ventral sucker is nearly as 2 : 3. The ventral sucker is situated almost entirely within the anterior third of the body, its distance from the oral sucker being only about 0·4 mm.

The genital aperture is situated anteriorly and ventrally, almost on the extreme left side of the body; it is about equidistant from the oral and ventral suckers. The cirrus is sometimes seen protruded from the aperture.

On the dorsal side of the body there is a structure which is the most remarkable feature of the species. At a short distance from the posterior end there is a very large circular or transversely elliptical aperture, extending sometimes almost completely across the body from side to side, in specimens which have not been flattened by pressure. This opening leads forward into a spacious sac or pouch. The latter does not interfere at all with the natural contour of the body externally, but its aperture is very easily seen, and it is not difficult under a dissecting-microscope to insert a fine needle into it and to see that it passes forward without resistance into the sac. This large opening appears to be the aperture of the excretory apparatus, the terminal portion of which is probably represented by the sac.

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* A generic diagnosis is given on p. 95.

INTERNAL ANATOMY.

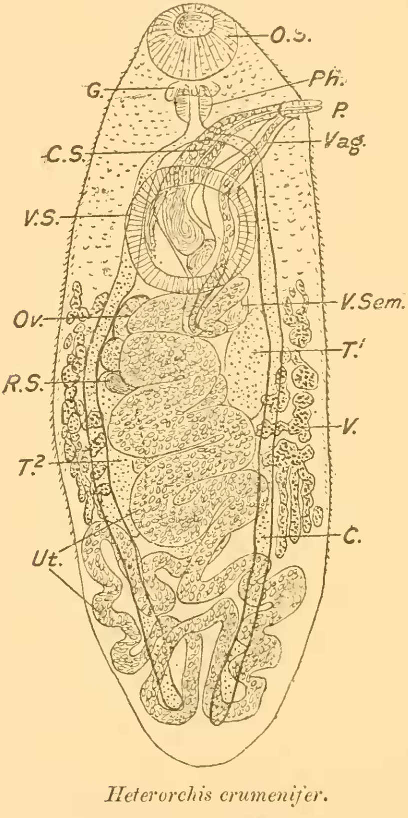
Alimentary Canal.—The oral sucker leads into a very short prepharynx, surrounded by a cluster of "salivary" glands. This is immediately followed by the almost spherical muscular pharynx, 0·18 mm. in length, and this again by a quite short œsophagus, dividing at once into two widely divergent intestinal cæca. The latter are unbranched, and extend nearly as far as the posterior end of the body and considerably beyond the yolk-glands, maintaining about the same width throughout.

Genital Organs.—As already observed, the genital pore is situated very far towards the left side of the body, and at some distance in front of the ventral sucker. It leads into a small common "atrium," at the base of which, side by side, are the openings of the cirrus-sac and vagina. The cirrus-sac is large and muscular, the muscles being arranged longitudinally. It takes a dorsal direction at first from its opening, then curves ventrally and over to the left side, ending behind or slightly to the left of the posterior edge of the ventral sucker. It contains a long eversible penis, which is apparently unarmed. The distal portion of the cirrus-sac is lined with large, conspicuous, and deeply staining "prostatic" cells, which extend back to the level of the ventral sucker. The inner end contains a voluminous vesicula seminalis, divided by a constriction into a larger proximal and a smaller distal portion. The latter has a well-developed coat of circular muscle-bands. Immediately in front of it there is a small oval "pars prostatica."

The two testes are unequal in size and asymmetrical in position. Both are elongate and sausage-shaped, with entire margins, but the right testis is almost twice as long as the left, the measurements being about 0·85 mm. and 0·5 mm. respectively. The anterior end of the right testis is in close contact with the ovary, and it extends backwards nearly as far as the posterior limit of the vitelline glands on that side. The left testis is situated somewhat further forward, beginning nearly at the same level as the ovary and close to the inner end of the cirrus-sac.

The ovary is somewhat lobate and lies on the right side, close to and just behind the ventral sucker. It measures about 0·35 mm. antero-posteriorly and 0·2 mm. transversely. Just behind the ovary there is a transversely elongated receptaculum seminis, lying somewhat obliquely and below

Fig. 1.

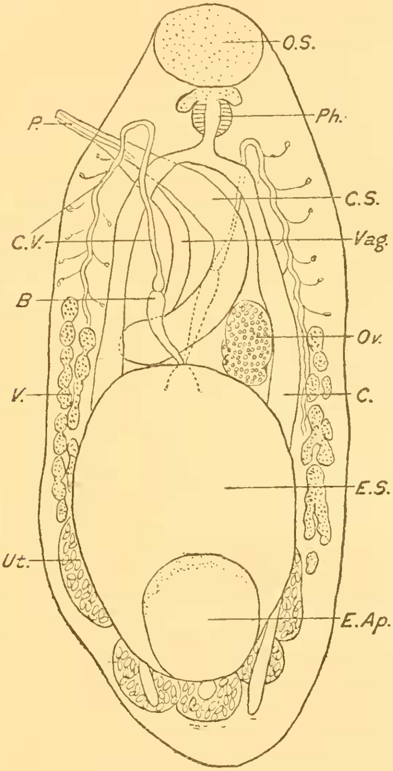


Heterorchis crumenifer.

Ventral view of the entire animal, × 34. *C.*, intestinal cæcum; *C.S.*, cirrus-sac; *G.*, salivary glands; *O.S.*, oral sucker; *Ov.*, ovary; *P.*, cirrus; *Ph.*, pharynx; *R.S.*, receptaculum seminis; *T.*^{1}, left testis; *T.*^{2}, right testis; *Ut.*, uterus; *V.*, vitelline glands; *Vag.*, vagina; *V.S.*, ventral sucker; *V.Sem.*, vesicula seminalis.

the anterior end of the right testis. Lying to the inner side of the ovary, and partly surrounding the receptaculum seminis, is the cluster of cells composing the shell-gland.

Fig. 2.



Heterorchis crumenifer.

Dorsal view of the entire animal (diagrammatic), to show the dorsal excretory sac, etc. *B.*, "bladder" of excretory vessel of left side (the dotted portions of the corresponding vessel and bladder on the right side are partly conjectural); *C.*, intestinal cæcum; *C.S.*, cirrus-sac; *C.V.*, collecting excretory vessel of left side; *E.Ap.*, aperture of excretory sac; *E.S.*, excretory sac; *O.S.*, oral sucker; *Ov.*, ovary; *P.*, cirrus; *Ph.*, pharynx; *Ut.*, uterus; *V.*, vitelline glands; *Vag.*, vagina.

The vitelline glands consist of somewhat large and irregular lobes, arranged along the sides of the animal from about the level of the hinder edge of the ventral sucker

Fig. 3.

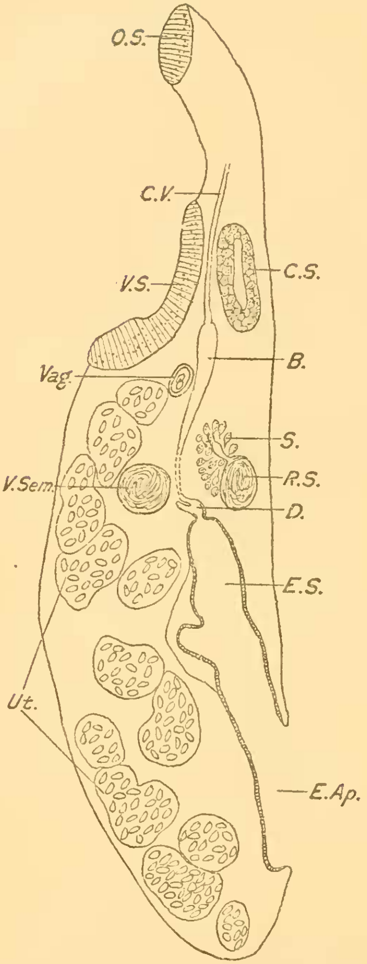
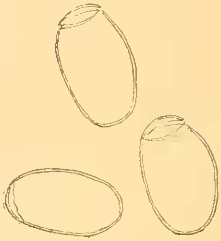


Fig. 4.



Heterorchis crumenifer.

Fig. 3.—Sagittal section, slightly to the right of the middle line (partly diagrammatic). *B.*, "bladder" of excretory vessel; *C.S.*, cirrus-sac; *C.V.*, collecting excretory vessel; *D.*, diverticulum of excretory sac; *E.Ap.*, aperture of excretory sac; *E.S.*, cavity of excretory sac (on the ventral side of the sac part of its epithelium has become separated from the basement-membrane); *O.S.*, oral sucker; *R.S.*, receptaculum seminis; *S.*, shell-gland; *Ut.*, uterus; *Vag.*, vagina; *V.S.*, ventral sucker; *V.Sem.*, vesicula seminalis.

Fig. 4.—Outline drawing of three eggs, highly magnified. In two of them the operculum is partly separated from the rest of the shell.

backwards for about a third of the length of the body. They are situated almost entirely externally to the gut-branch on either side. The two vitelline ducts cross the body just behind the ovary, on the dorsal side, forming a straight line with one another. Owing to the obscurity caused by the excessive development of the uterus at this level, the precise relationships of the complex of organs and ducts belonging to the female apparatus have not been worked out, and the presence of Laurer's canal remains uncertain.

The uterus is very well developed and voluminous in most of the specimens. Passing backwards from its origin behind the ventral sucker, it forms a double sinuous loop in the hinder end of the body. It then turns forward and runs, still with a very sinuous course, up the middle of the body. In this region it becomes much swollen, giving the animal a very prominent contour on the ventral side, and is densely packed with eggs. Finally, it opens into a thick-walled vagina, which begins at the level of the hinder edge of the ventral sucker, and runs forward with a curve almost parallel to the cirrus-sac, with which it is about equal in length. The vagina has a strong coat of circular muscles. The fully formed eggs contained in the uterus are oval, and have a moderately thick brownish shell, with a distinct cap at one end, which is easily separated by slight pressure on the cover-glass. The eggs measure 0·04 mm. in length and 0·02 mm. in breadth. In a very young specimen, in which there were as yet few eggs in the uterus, they were found to have precisely the same dimensions as in the mature individuals.

Excretory Organs.—The excretory system presents in this species an apparently unique condition. The presence of a very large and peculiar sac, with a comparatively enormous aperture, on the dorsal side, has already been mentioned. This sac appears to be lined with a special epithelium, consisting of a single layer of rather tall cells. Unfortunately, owing to the poor fixation of the material, I am unable to describe the nature of this epithelium more precisely, or to decide whether it is ciliated or not. At all events, it is clear that the sac is not merely lined with a continuation of the external cuticle of the animal. The cavity of the sac is usually filled with a mass of loose matter, which may be a product of excretion or may be of mucous nature.

At its anterior end the sac gives off a small ventral diverticulum, into which, apparently (though not directly), the two main collecting vessels of the excretory system empty their contents. I have experienced great difficulty in seeing clearly the termination of both of these tubes in the same preparation owing to the manner in which they are obscured by the other organs. The diagram (fig. 2) shows in a schematic manner their probable relation to each other and to the dorsal sac. The proximal end of each tube appears to open into a small, elongate, bladder-like organ, which communicates with the diverticulum of the sac. Each tube runs forward to about the level of the hinder end of the pharynx, then doubles immediately backwards to run down the side of the body with a sinuous course, giving off frequent fine branches which end in flame-cells scattered among the parenchyme. The tubes are finally lost among the vitelline glands on either side. The "bladder" and collecting vessel of the left side lie dorsally to the cirrus-sac, vagina, and intestinal cæcum, while the apparatus of the right side appears to pass ventrally below these structures.

NOTE ON THE AFFINITIES OF THE SPECIES.

On a general consideration of its structural characters this form seems to approach most closely to the Trematodes of the family Lepodermatidæ. Among the important features of this family (Odhner, 1911, p. 22) are the following:—

The skin is armed with scales or spines, which generally occur all over the body. The oral and ventral suckers are moderately close together. The alimentary canal consists of prepharynx, pharynx, œsophagus, and two simple intestinal branches. The excretory vesicle is Y-shaped, the division into the two arms of the Y occurring just behind the shell-gland and associated organs. The genital pore is situated typically at a short distance in front of the ventral sucker, but more or less to the left of the middle line. [In *Renifer* and *Ochetosoma* this displacement is very marked, and the pore is nearly at the edge of the body; it is also situated far to the left in *Lechriorchis*.] The cirrus-sac is usually curved in a crescentic manner from its opening to its inner end, is provided with conspicuous longitudinal muscles, and has an internal seminal vesicle, a pars prostatica, and an eversible cirrus. The ovary is on the right side, behind the ventral sucker. The left testis is usually somewhat in front of the right. A receptaculum seminis may or may not be present. The vitelline glands are at the sides of the body in the middle region. The eggs are from 0·02 to 0·05 mm. in length.

In almost all the particulars enumerated above the present species agrees, as will be seen from the foregoing description. The only points in which it is exceptional are the unequal size of the testes and the condition of the excretory system, with the peculiar dorsal sac and wide aperture. In these respects, however, it appears to differ from any other known group of Trematodes as much as from the Lepodermatidæ. Taking into consideration, therefore, its general agreement with the members of this family, I am inclined to the view that it should be included here and regarded as a specialized form, whose peculiarities seem to require the creation of a new genus. The genera to which it appears to be most closely allied are *Ochetosoma*, Braun (1901, 1902), *Renifer*, Pratt (1903), and *Lechriorchis*, Stafford (1905; redefined by Nicoll, 1911). To all of these genera it bears a very close resemblance in most of its morphological features, among which the displacement of the genital pore towards the left side is especially important; but it differs from all of them alike in the shape and unequal size of the testes, in the presence of a well-developed receptaculum seminis, and in the unique condition of the excretory apparatus. In all the three genera mentioned the testes are equal in size, more or less lobate, and not elongate, while the excretory vesicle has the usual shape of a Y, already mentioned as characteristic of the Lepodermatidæ. In *Renifer ellipticus* and *R. elongatus*, Pratt (1903), the stem of the vesicle widens considerably in the middle, and the same seems to be the case in *Lechriorchis validus*, Nicoll (1911); but in all these cases the external pore is small and situated at the posterior end of the body.

To what extent the specialization of this parasite may have been brought about by the fact of its inhabiting a host so specialized in structure and mode of life as *Protopterus* is a question of great interest, but one to which it is scarcely possible to attempt an answer. One is tempted to speculate on the possible function of the dorsal sac with its enormous aperture, and to question whether it is in any way an adaptation to the circumstances which arise owing to the æstivation of the host during the dry season—whether, for example, it is a reservoir for the excretory products during this period, or whether it may have an additional function, *e. g.*, in subserving respiration.

Quite apart from this question of function, the homologies of the various parts of the excretory system are by no means clear. It would be of great interest to decide whether the dorsal sac really represents the usual excretory vesicle of the digenetic Trematodes, or whether it is a new structure specially developed, possibly as an invagination of the external skin. The latter view has a serious drawback in the existence of a special lining epithelium in the sac, which differs totally in character from the outer covering of the body.

On the other hand, if the sac is homologous with the usual vesicle, the enormous size of its aperture and its dorsal position have to be accounted for, and there remain also as problems the terminal bladders of the two collecting vessels and the small diverticulum of the sac into which they apparently open. The histology of the walls of these various parts might be expected to throw some light on the question, and the evidence of my material, so far as it goes, seems to be that the thick epithelium of the sac is not continued into the diverticulum and the two "bladders," but that the latter have thin walls consisting of comparatively flattened cells, while the diverticulum has a considerably thinner epithelium than the large sac. Owing, however, to the imperfect preservation for histological details, it is impossible to lay much stress on such a point.

On the whole, I am inclined to the view that the sac and its diverticulum together probably represent the stem of the **Y**-shaped excretory vesicle of the Lepodermatidæ, the two terminal bladders of the collecting-tubes being the homologues of the divergent anterior branches. Upon this view, the dorsal sac is not a new invagination from the exterior, but a modification of the terminal portion of the vesicle. How it has been developed to this extraordinary extent, and what may be the advantage gained by having the aperture enlarged from a minute pore to a gaping opening nearly as wide as the whole animal, and, instead of being situated, as usual, at the posterior end of the body, moved forward to a position considerably anterior to this on the dorsal side, are at present unanswerable questions.

I am not aware of any case among Trematodes in which the excretory pore has a similar size and position. In certain forms (e. g., *Urogonimus*) in which the genital pore is situated at the hinder end of the body, the excretory pore is displaced somewhat to the dorsal side. But in other Digenea, I believe, where the excretory pore or pores are not terminal, they open on the ventral side. In all cases the pores are minute, and closed either by a special sphincter muscle or by the ordinary musculature of the body-wall (Braun, 1893, p. 641).

It is an interesting and somewhat remarkable fact that the members of the three genera (*Ochetosoma*, *Renifer*, and *Lechriorchis*) which have already been mentioned as, apparently, the nearest relatives of the present species are, with very few exceptions, parasitic in snakes. Odhner has pointed out (1911, p. 55) that these genera, together with *Pneumatophilus*, Odh., and *Leptophallus*, Lühe, form within the family

Leptodermatidæ a well-marked group of parasites inhabiting the mouth, lungs, œsophagus, and stomach of snakes. It would seem that most of them have a preference for situations more or less accessible to the outer air. It is not a little striking, therefore, though probably a pure coincidence, that an allied form is now found inhabiting a fish which is specially adapted for breathing air. In this case, however, the parasite lives in the intestine, and I have no information to show that it could obtain access to the air. The relationship, moreover, if any, between the Dipnoi and the Reptilia is of the remotest character, and the presence of related parasites in both groups probably has no special significance.

The following is a provisional diagnosis of the new genus:—

HETERORCHIS, gen. nov.

Lepodermatidæ; with body flattened anteriorly, but much swollen posteriorly, covered at the anterior end and on the sides to near the posterior end with small scales. Œsophagus very short; intestinal cæca extending nearly to the posterior end of the body. A very large excretory sac is present on the dorsal side, with a very wide aperture situated dorsally at some distance from the posterior end. Two main excretory vessels present. Genital aperture situated midway between the oral and ventral suckers, almost at the extreme left side of the body. Cirrus-sac long and curved, containing a large vesicula seminalis (divided into a non-muscular proximal portion and a muscular distal portion), a small bulbous pars prostatica, numerous large prostatic cells, and a long eversible cirrus. Testes elongate, with entire margins; unequal in size, the right testis being considerably longer and situated farther back than the left. Ovary lobate, on the right side, behind the ventral sucker. A receptaculum seminis present, behind the ovary. Yolk-glands occupying about the middle third of the body, arranged in irregular masses along the sides. Uterus forming a double sinuous loop at the posterior end of the body, and having a very wide, sinuous ascending limb. Vagina running nearly parallel to the cirrus-sac, long and provided with strong circular muscles. Eggs 0·04 *mm. in length.*

Type, *H. crumenifer*, sp. n.—with the characters of the genus.

Hab. Intestine of *Protopterus æthiopicus*: Lake Victoria, Uganda.

Syntypes in the British Museum (Natural History).

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XIV.—*Descriptions and Records of Bees.*—LXIX.

By T. D. A. COCKERELL, University of Colorado.

Parasphecodes cervicalis, sp. n.

♀.—Length 10–11 mm.

Black, robust; closely allied to *P. dissimulator*, Ckll., differing thus:—Face narrower, eyes more converging below; flagellum only very faintly reddish at end; stigma dark rufo-fuscous; nervures more slender, fuscous; wings variable in tint, but not so red; dark hair on outer side of hind tibiæ dark sooty; brush at apex of hind basitarsus not brilliantly coloured; tubercle on second ventral segment hairy, but without a well-defined tuft. It is easily known from *P. noachinus*, Ckll., by the much more densely punctured mesothorax and the more finely and closely punctured first abdominal segment.

Hab. Eaglehawk Neck, Tasmania, Feb. 12–Mar. 3, 1913 (*R. E. Turner*). British Museum.

At Mt. Wellington, Tasmania, Jan. 15–Feb. 6, 1913, Mr. Turner took specimens of *P. plorator*, Ckll.

Parasphecodes latissimus, sp. n.

♀.—Length about or almost 10 mm., abdomen 3·25 mm. broad.